

Solar Simulation for the CREST Preflight Thermal-Vacuum Test at B-2

In June 2011, the multi-university sponsored Cosmic Ray Electron Synchrotron Telescope (CREST) has undergone thermal-vacuum qualification testing at the NASA Glenn Research Center (GRC), Plum Brook Station, Sandusky, Ohio. The testing was performed in the B-2 Space Propulsion Facility vacuum chamber. The CREST was later flown over the Antarctic region as the payload of a stratospheric balloon. Solar simulation was provided by a system of planar infrared lamp arrays specifically designed for CREST. The lamp arrays, in conjunction with a liquid-nitrogen-cooled cold wall, achieved the required thermal conditions for the qualification tests.

The following slides accompanied the presentation of the report entitled “Solar Simulation for the CREST Preflight Thermal-Vacuum Test at B-2”, at the 27th Aerospace Testing Seminar, October 2012. The presentation described the test article, the test facility capability, the solar simulation requirements, the highlights of the engineering approach, and the results achieved. The presentation was intended to generate interest in the report and in the B-2 test facility.



“Solar Simulation for the CREST Preflight Thermal-Vacuum Test at B-2”

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**Aerospace Testing Seminar, Los Angeles, CA
October 16-18, 2012**



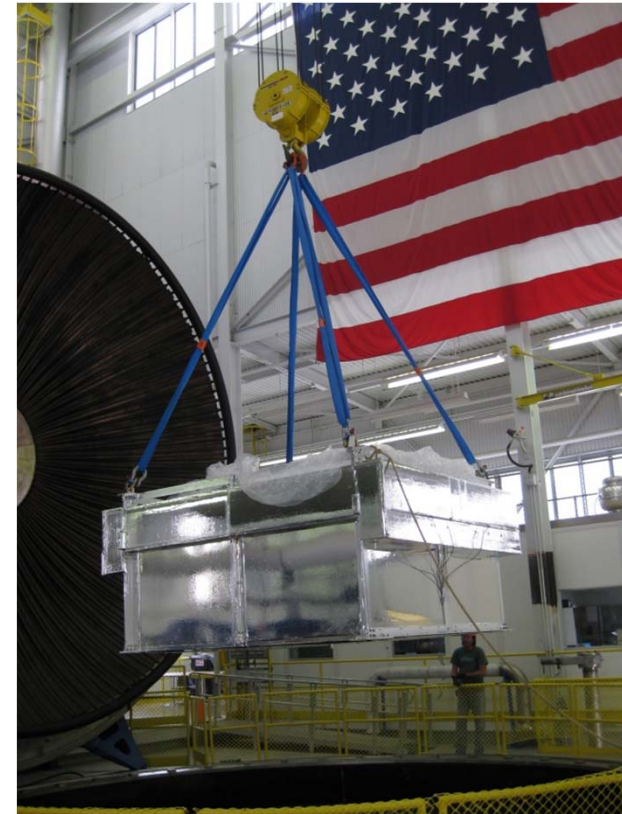
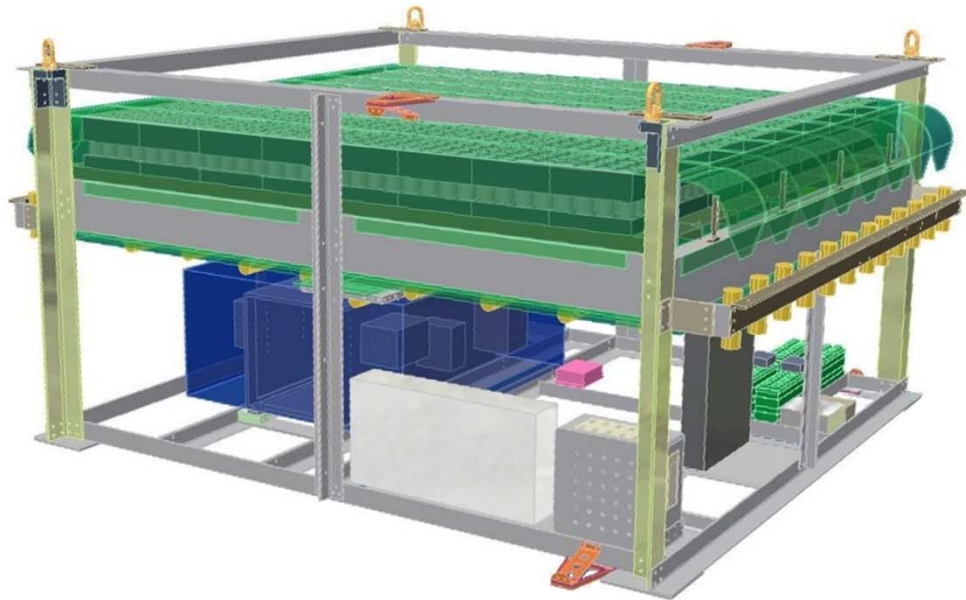
OUTLINE

- Introduction
- Solar Simulation Requirements
- Engineering Approach
- Optimizing Flux Uniformity
- Setting the Infrared Flux Density Levels
- Final Solar Simulation Layout
- Conclusion



INTRODUCTION

- Cosmic Ray Electron Synchrotron Telescope (CREST)
 - Stratospheric balloon payload flown over Antarctica
 - 120,000 ft. Altitude simulation (3 Torr)
 - Solar simulation (LEO Sun)





INTRODUCTION

- Spacecraft Propulsion Research Facility (B-2)
 - Vacuum Chamber
 - Liquid Nitrogen Cold Wall
 - Infrared Thermal Simulator





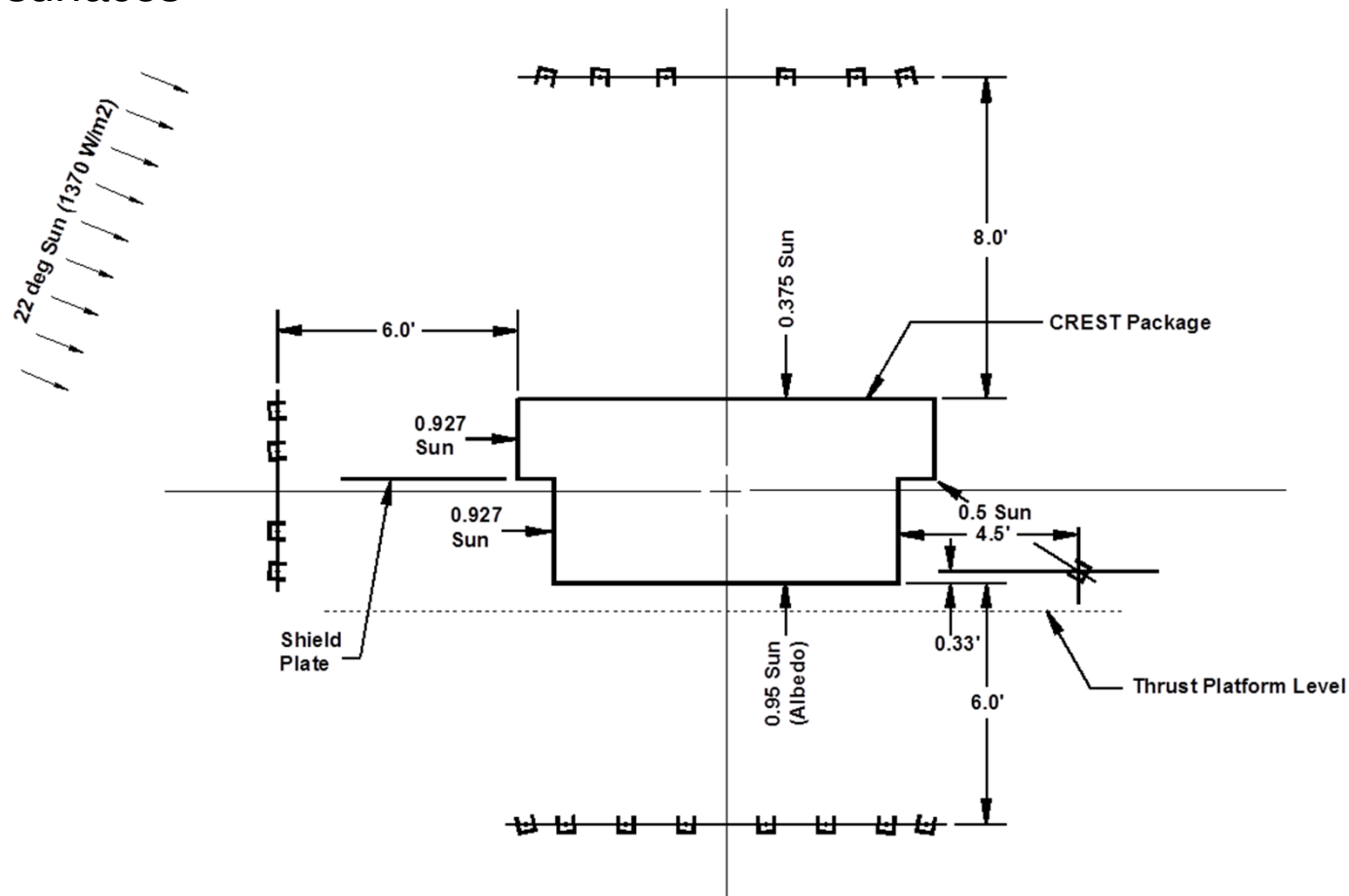
SOLAR SIMULATION REQUIREMENTS

- With Chamber Pressure at 3 Torr and cold wall at 77 K provide:
 - One Low Earth Orbit (LEO) sun equivalent at 22 degrees incident on Front and Top surfaces of test article
 - Earth's Albedo at 0.65 and 0.95 LEO sun equivalent incident on bottom surface
 - Manually controlled auxiliary heating at 0.5 LEO sun equivalent at rear of test article
 - Incident Flux Uniformity (+/- 5%) by mutual agreement



ENGINEERING APPROACH

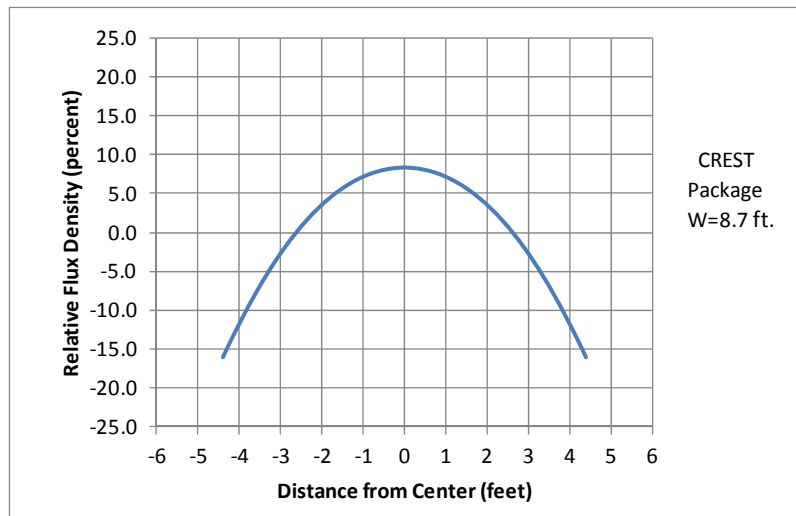
- Resolve 22 degree LEO sun into horizontal and vertical components
- Provide Individual planar arrays incident on front, top, and bottom surfaces



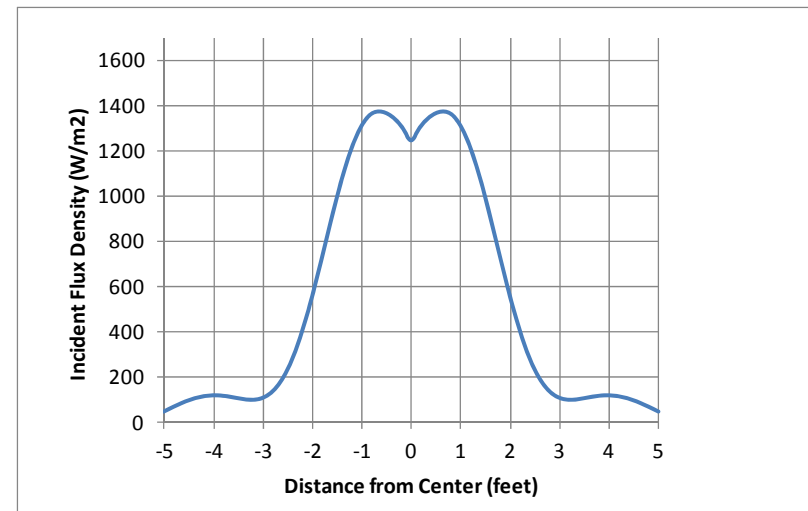


ENGINEERING APPROACH

- Assemble planar arrays from 12 ft. IR line sources borrowed from existing B-2 thermal simulator
- Accept inherent longitudinal flux fall-off of line sources
- Optimize transverse flux uniformity based on theoretical prediction



Longitudinal Flux Distribution

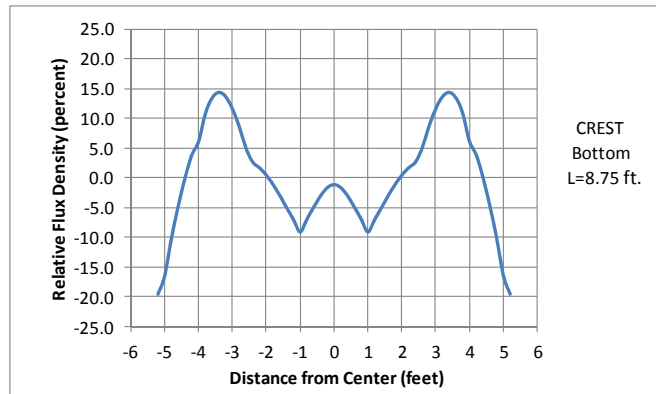


Transverse Flux Distribution

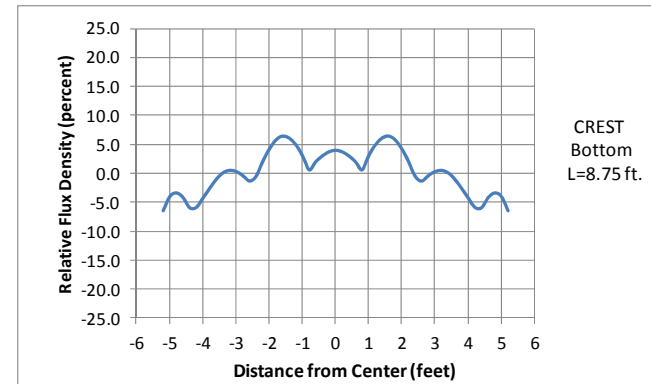


OPTIMIZING FLUX UNIFORMITY

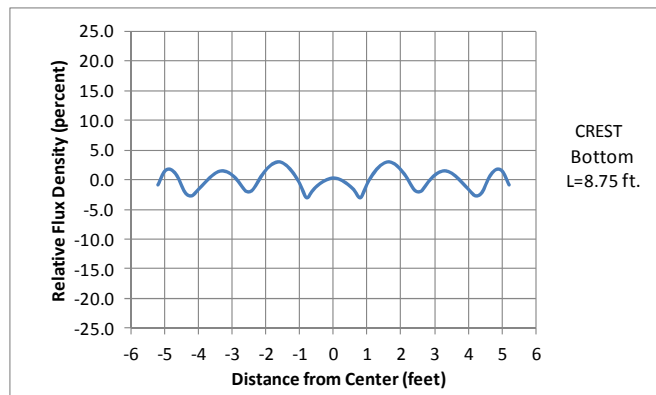
Optimization example: CREST bottom zone



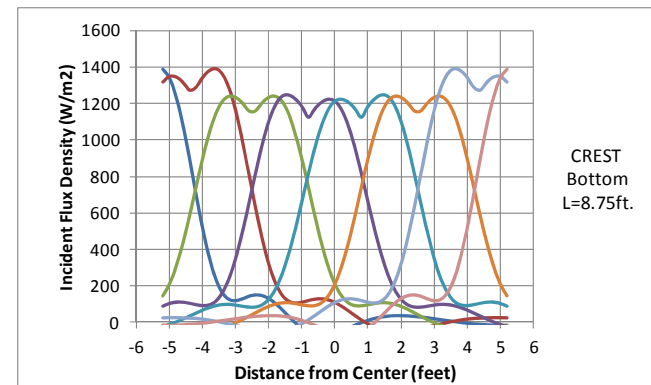
Not Optimized



Tilt Angles Optimized



Tilt Angles and Power Ratios Optimized

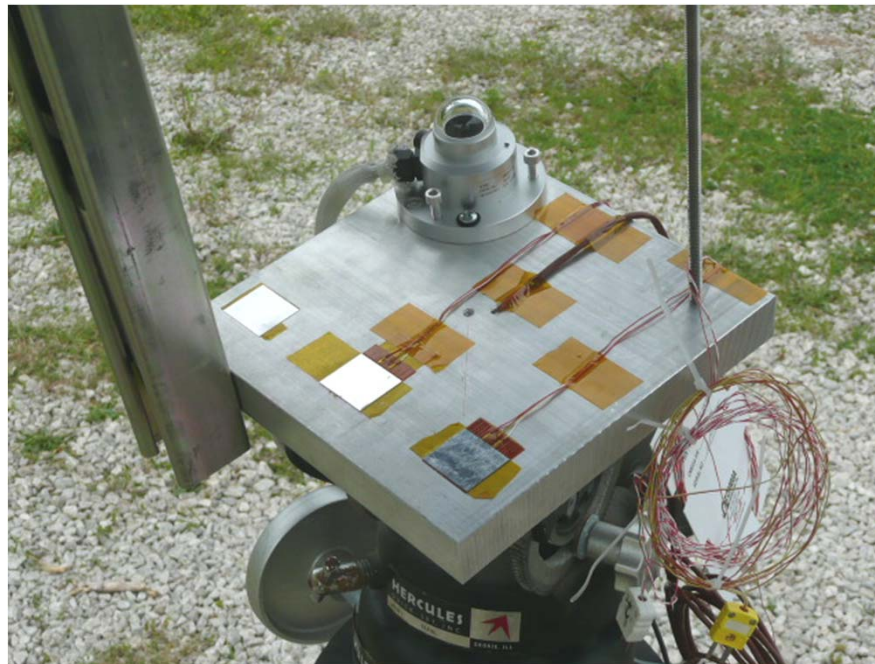


Line Array Contributions Superimposed



SETTING THE INFRARED FLUX DENSITY LEVELS

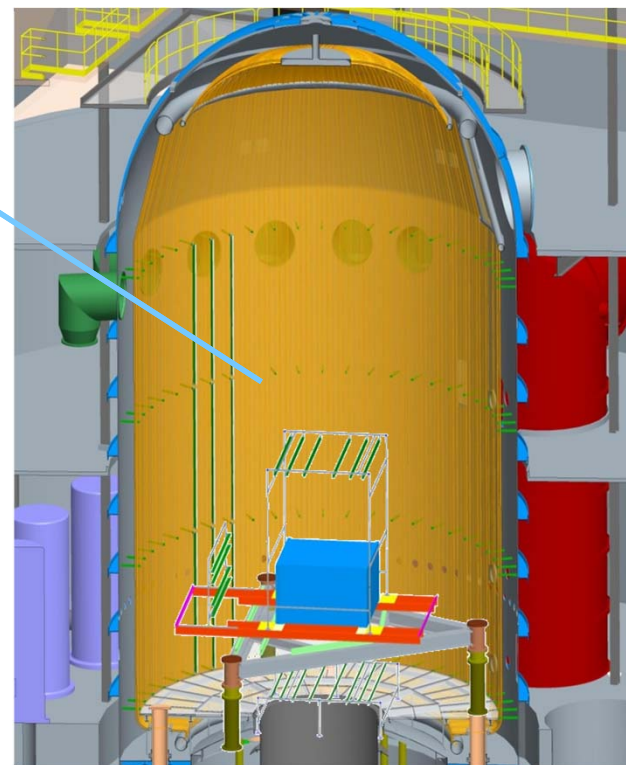
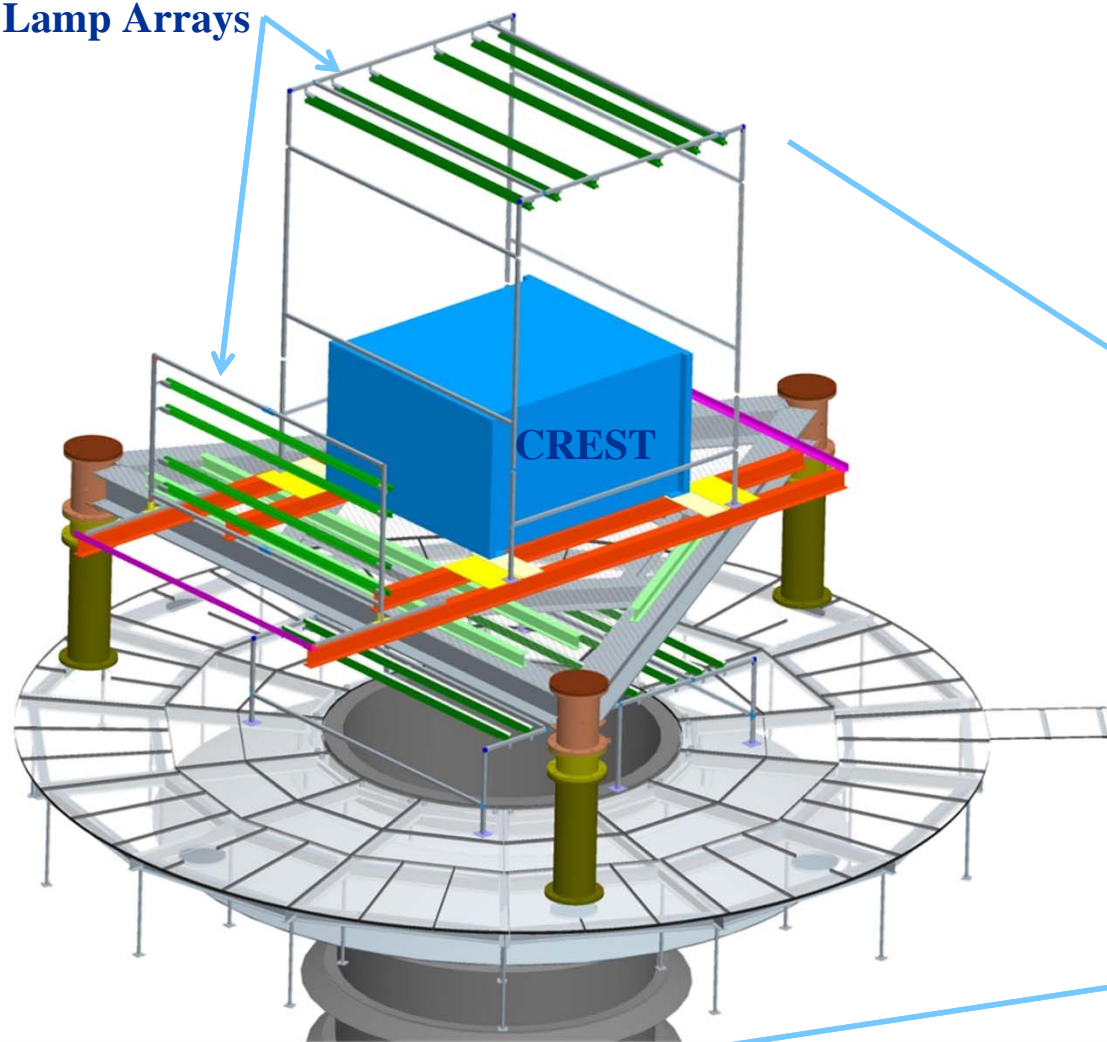
- Set IR flux levels to produce heating equivalent to 22 degree LEO sun incident on the surface films
- IR flux level settings take into account optical properties of surface films and spectral differences of solar vs. IR illumination
- Provide closed-loop control of incident flux density based on pyranometer feedback





FINAL SOLAR SIMULATION LAYOUT

Lamp Arrays





CONCLUSION

- Report emphasizes development of planar arrays built from line sources, and the supporting theory
- Mathematical modeling details are described in report
- Calibrated IR lamp arrays are a low-cost alternative to a true collimated xenon arc solar simulator
- Customer (CREST) was very pleased with the solar simulation achieved

